Summary of Historical Chilkat Lake Sockeye Salmon Stock Assessment Projects

by

Brian K. Holder
Renate Riffe

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AUTHORS

Renate Riffe is a fishery biologist employed by the Alaska Department of Fish and Game, Division of Commercial Fisheries, P.O. Box 240020, Douglas, Alaska 99824.

Brian Holder is a student completing his Bachelor of Science degree at University of Alaska, Southeast, 11120 Glacier Highway, Juneau, Alaska 99801.

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

ABSTRACT

Chilkat Lake has historically been among the largest sockeye salmon (*Oncorhynchus nerka*) producers in Southeast Alaska. The modern industrial commercial fishery began in the early 1880s. Initially, sockeye salmon bound for Chilkat Lake were harvested in a gauntlet fishery in Icy Strait and Lynn Canal, along with stocks from throughout Northern Southeast Alaska. The peak historical catches for sockeye salmon in Northern Southeast Alaska occurred between 1900 and 1920, and declined steadily until the mid 1970s. Scale pattern analysis was instituted in 1981 to differentiate Chilkat Lake sockeye salmon from Chilkoot Lake sockeye salmon. The Alaska Department of Fish and Game began to count sockeye escapement into Chilkat Lake at a weir in 1967. Mark–recapture estimates conducted since 1995 indicate that the weir counts underestimate the actual escapement by 50 percent or more. Managers are unable to closely manage this system because of a lack of precise escapement estimates. From 1994 to 1997 and in 2000, the Northern Southeast Regional Aquaculture stocked sockeye fry into Chilkat Lake, based on a recommendation from ADF&G limnologists. Although ADF&G and Northern Southeast Regional Aquaculture Association developed thresholds for zooplankton abundance and smolt size and numbers, to prevent fry stocking under poor rearing conditions, the fry stockings, in conjunction with high escapements, appear to have caused marked declines in the zooplankton populations, and reduced the lake's potential for sockeye production.

INTRODUCTION

Chilkat Lake is a clear lake that lies near the upper end of the "Inside Passage" of Southeast Alaska, known as Lynn Canal, about 30 km northwest of the city of Haines (Figure 1). The lake has a water area of $9.84 km^2$, a mean depth of 32.5m, a volume of $0.319 km^3$, and lies at an elevation of 53m. Chilkat Lake is long and crescent shaped, measuring 24.9 km in length. The upper portions of the Chilkat drainage extend into Canada, through the coastal mountains.

History

Chilkat means "salmon storehouse" in the Tlingit language. The Tlingits residing near present day Haines and at Klukwan, Alaska traded salmon and eulachon extensively into Interior Alaska and the Yukon Territory of Canada, in exchange for furs, hides, and copper (Emmons, 1991). An industrial fishery in northern Southeast Alaska began in the early 1880s, and was fully utilizing the resource by 1901. While the catches are not delineated by stock, Chilkat and Chilkoot River sockeye salmon are believed to have comprised the majority of Northern Southeast Alaska's catch, with Taku River sockeye stocks making minor contributions (Figure 2). Other local stocks, such as Hocktaheen Lake, comprised miniscule portions of the harvest.

Methods and location of harvests have changed dramatically over time. The Tlingits tend to gaff and trap fish within the river, or to use beach seines near stream and river mouths. The modern, industrial fishery in northern Southeast Alaska began with the establishment of the first salmon cannery in Lynn Canal in 1883. The non-native fishing fleet, using gillnets, moved into the area quickly, and became more prolific in the subsequent years. After 1900, fish traps supplanted gillnets and beach seines as the preferred method of harvest. While the Tlingits concentrated their efforts within rivers and around river mouths, the non-native fishermen began intercepting fish further from their spawning destinations. The Icy Straits commercial salmon fisheries began in 1900. Originally, the Icy Straits fishery targeted local stocks of sockeye salmon, but with the increasing use of fish traps, the fishery harvested large numbers of salmon bound for the Chilkat, Chilkoot, and Taku rivers (Rich and Ball 1933).

At the height of the fishery, from 1900 until the 1930s, returning salmon had to navigate a maze of traps set from Cross Sound to Chilkat Inlet. One of the most productive trap locations was the mainland shore between Excursion Inlet and Point Couverden, which had nearly 50 traps, and accounted for a minimum of 50% of the annual catch in the Icy Strait district. Other desirable trap locations for sockeye salmon included the Inian Islands, Pleasant Island, Porpoise Island, Surge Bay, and the western side of the Mansfield Peninsula. In 1905, the number of fish taken in Lynn Canal began to decline; the Icy Straits sockeye harvests began to outstrip the Lynn Canal harvests (Rich and Ball 1933). Between 1900 and 1920, the average harvest of sockeye salmon for northern Southeast Alaska was 1.5 million fish.

The federal government began restricting trap locations in 1918. In 1922, the government also prohibited in-river fishing, as well as fishing near mouths of rivers and streams. In 1926, traps and purse seines were prohibited in Lynn Canal north of 58º 26′north latitude (Rich and Ball

1933). These measures did not halt the decline in overall harvests (Figure 2). The mean decadal sockeye catch declined from 1.47 million fish in 1920, to 960 thousand fish in 1930, and to 780 thousand fish in 1940. Between 1941 and 1960, the mean catch had declined to 430 thousand fish.

Due to diminishing revenue, many commercial fishing companies dismantled fish traps in Icy Strait and Lynn Canal. Fish traps were eventually outlawed at statehood, but the gauntlet fishery continued until 1975, when the state implemented interception-reducing restrictions (McPherson 1990). The lowest recorded catch for Northern Southeast Alaska was 57 thousand sockeye salmon in 1973, which was due to a combination of poor ocean survival and depleted populations. The mean sockeye catch between 1980 and 2002 was 453 thousand fish.

There is little specific information available about the sockeye stocks in Lynn Canal before statehood in 1959. In 1950, scales were collected from sockeye salmon in Chilkat Inlet to document the difference between Chilkat Lake and Chilkoot Lake fish. The study was not part of an integrated research plan.

The next data-collection effort began in 1967, when the Alaska Department of Fish and Game installed a weir at the outlet of Chilkat Lake. In 1976, ADF&G initiated a catch sampling program. Working with data from the catch sampling program and weir counts, McPherson (1990) developed a management system for the Lynn Canal commercial gillnet fishery, and calculated an escapement goal range of 52,000 to 106,000 sockeye salmon for Chilkat Lake. In the 1980s, the Northern Southeast Regional Aquaculture Corporation (NSRAA) expressed an interest in enhancing the Chilkat Lake sockeye salmon stock. Based on the findings of a limnology study conducted between 1987 and 1991, NSRAA received permission in 1993 to take eggs from sockeye salmon spawning in Chilkat Lake, incubate the eggs at a hatchery, and stock newly hatched fry into the lake the following year. The enhanced fry were marked to differentiate them from wild fry. In 1999, NSRAA began to work cooperatively with ADF&G in estimating escapements into Chilkat Lake. The last stocking of sockeye fry into Chilkat Lake occurred in 2000.

Catch

Commercial

Currently, the bulk of Chilkat Lake sockeye salmon are harvested by gillnet in Lynn Canal. Estimated Chilkat Lake sockeye catch contributions between 1976 and 2002 have ranged from a low of 31,000 fish in 1980, to a high of 168,000 in 1986 (Table 1). The commercial catch has commonly been greater than the number of fish counted at the weir during this period.

During years of high pink salmon (*Oncorhynchus gorbuscha*) abundance, a commercial purse seine fishery that harvests sockeye salmon incidentally is opened along the shore of Hawk Inlet on Admiralty Island (Subdistrict 112-16). During the month of July, fishers are allowed to harvest fish north of Point Marsden, until a harvest cap of 15,000 sockeye salmon is reached (5AAC 33.366). This pink salmon fishery incidentally harvests sockeye salmon from the Chilkat, Chilkoot, and Taku systems, other smaller wild stocks, and returns from Snettisham Hatchery releases. From 1989 to the present, a July fishery on the Hawk Inlet shore has occurred 6 times, for an average sockeye harvest of 10,000 fish.

In 1976, the Alaska Department of Fish and Game implemented a catch sampling program that has continued to the present. This sampling program was revised in 1981 to remedy deficiencies in sampling strategies, and to differentiate between Chilkoot Lake and Chilkat Lake sockeye stocks via scale pattern analysis (Marshall et al. 1982). McPherson (1990) refined the method of allocating commercial sockeye catches to the major stocks in Lynn Canal – using scale pattern analysis together with weir counts from the Chilkat and Chilkoot Rivers to develop a Ricker stock-recruit analyses and an inseason management system for the two rivers.

Subsistence

Historically, the residents of the Haines area and the Native village of Klukwan used Chilkat Lake salmon for trade and subsistence. With the advent of modern commercial fishing, they were required to share the salmon resources. There is still a considerable subsistence fishery that uses the resource today, both by Alaska Natives and non-natives.

ADF&G Sport Fish Division monitors annual harvests through the use of subsistence permits. Subsistence users record catches over the entire season on these permits, which they then return to ADF&G. The Department of Fish and Wildlife Protection enforces subsistence fishing regulations, and often cites people for fishing in closed waters, unattended fishing gear, and failure to document catches on subsistence permits. Subsistence fishers may also have their subsistence privileges suspended for failure to submit harvest information on the subsistence permit.

Fish and Game personnel have been meeting with local residents, in an effort to increase reporting of subsistence harvests. ADF&G subsistence division acquires in-depth information on subsistence fishing through Household Harvest Surveys. These surveys are performed when funding is available. Results of the surveys and the subsistence permits indicate that underreporting by subsistence users is a problem (McPherson 1990).

Escapement

From 1967 to 1995, ADF&G operated a weir at Chilkat Lake. For sockeye salmon, travel time between the commercial fishery and Chilkat weir was often 30 days or more. Thus, weir counts were not timely enough for inclusion in inseason management decisions that affected the commercial fishery.

In 1995, ADF&G began a mark–recapture project that used fish wheels in the Chilkat River as marking platforms. At that time, three different methods were compared in order to determine the most accurate method for estimating escapement. The methods compared were: (1) weir counts, where fish are counted as they pass the weir; (2) weir/mark–recapture counts, where fish are marked at the weir and later collected by seining on the spawning grounds; and (3) fish wheel/mark—recapture, where fish are marked at the fish wheels and either captured at the weir or collected by seines on the spawning grounds. Through this project, ADF&G biologists concluded that the previous method for escapement estimates, weir counts, undercounted the actual escapement. Of the three methods used in 1995, the weir/mark—recapture method was believed to be the most accurate. The fish wheel mark—recapture method allowed sampling of multiple stocks within the drainage. The 1995 fish wheel count was 284,000 sockeye salmon, 4.8 times larger than the weir count.

In 1996, ADF&G chose to use their limited funding to operate the fish wheel/mark—recapture project. In the original fish wheel mark—recapture study, fish were marked at the fish wheels, and recaptured on the spawning grounds. However, salmon marked in the latter part of the migration did not arrive on the Chilkat Lake spawning beds until very late in the year, when ice on the lake made sampling difficult or impossible. The 1996 estimates did not include these fish, thereby underestimating the total escapement (Kelley and Bachmann 2000). In 1999, NSRAA, by a cooperative agreement with ADF&G, operated the weir as a recovery platform for the fish wheel mark—recovery. In addition to examining fish for marks, NSRAA personnel counted the fish passage through the weir. NSRAA personnel were required to sample 10% of the fish that were counted through the weir, for marks made at the fish wheels.

Physical shortcomings of the weir, as well as stream flow and turbidity, contribute to the undercounting at the weir. The weir does not rest on a solid substrate; the pickets must be set in mud. Over the season, mud under the pickets probably washes out, leaving spaces through which fish can swim. In order to reduce the chance of the weir washing out, weir crews open the boat gate to relieve pressure during periods of high water. The outlet to Chilkat Lake also experiences flow reversals, whereby glacial water flows into the lake. The outlet then becomes turbid, and counting fish becomes difficult. In 1976, in order to accommodate river traffic into Chilkat Lake, a boat gate was constructed. There has been a marked increase in traffic since that time, and the boat gate must now be opened upwards of a dozen times a day during fishing season. Boat motor noise can drive large numbers of frightened fish through the weir without being counted. As a result of these influences, we do not know the extent of undercounting at the weir between 1967 and 1994. Between 1999 and 2002, the mark–recapture escapement estimates ranged from 1.7 to 2.8 times higher than their respective weir counts (Table 2).

The fish wheel mark—recapture estimates are also problematic. Fish marked at the wheels travel throughout the drainage, not just to Chilkat Lake. There is no effective means of visually distinguishing Chilkat Lake fish from other stocks at the fish wheel site. Scale samples are collected at the fish wheels so that scale readers can estimate the proportion of fish bound for Chilkat Lake, using scale pattern analysis. For certain age classes, it is difficult to distinguish Chilkat Lake fish from other stocks in the system. In recent years, the freshwater zone on Chilkat Lake sockeye scales has changed. These scales now more closely resemble scales from sockeye stocks elsewhere in the watershed (Iris Frank, ADF&G, *personal communication)*. This change in the freshwater zone may be due to a reduction in zooplankton populations in Chilkat Lake, which reduces the growth of scales while Chilkat Lake sockeye juveniles are in fresh water. The changes in scale appearance have not yet affected categorizing sockeye salmon into different stocks.

In 2003, ADF&G began a radiotelemetry project in the Chilkat River drainage. In this study, salmon will be marked with radio tags. Radio towers, placed along the Chilkat River at various locations upstream of the marking site, will record the migration of these fish. The information from this study, in conjunction with abundance estimates from the fish wheels, will help biologists determine the proportion of fish that are passing the weir uncounted. Radio telemetry data from 2003 has documented both that sockeye salmon swim past the weir uncounted when the boat gate is shut, and that fish migrate into the lake during flow reversals.

McPherson (1990) developed an inseason model to manage the Lynn Canal commercial fishery, which included an overall escapement goal range of 52,000 to 106,000 sockeye salmon for Chilkat Lake. The overall escapement goal was partitioned, so that 14,000 to 28,000 fish were to be from the early part of the migration, and 52,000 to 78,000 fish were to be from the latter part of the run. The analysis and recommended escapement goals were based on the assumption that the weir counts were accurate. However, based on the results of the mark—recapture experiments, weir counts undercounted the actual escapement by 50% or more. Thus, the original analysis was based escapement estimates we now know to be too low.

When McPherson conducted the Ricker stock recruit analysis of Chilkat Lake sockeye salmon, he split the migration into 2 stocks, and analyzed each stock separately. The differentiation was based on migratory timing and number of years spent in freshwater. Most of the fish in the first half of the spawning migration spend one year in fresh water (age-1), while the fish in the last half of the spawning migration usually spend 2 years in fresh water (age-2). Size differentiation during the summer following hatching, and the inability of the smaller fish to reach the size threshold for smoltification, may explain the presence of age-1 and age-2 fish in the sockeye run, rather than presence of separate stocks.

Several spawning areas have been identified in Chilkat Lake, and are used over a protracted period, from late August into December (Randall Bachman, ADF&G, *personal communication*). We do not know whether Chilkat Lake sockeye fish using separate spawning areas behave as separate stocks. Differences in time of spawning may have a greater influence on stock differentiation than differences in spawning area. Whether the early and late runs are considered separate stocks, all sockeye salmon fry interact with each other within the lake, and are subject to many of the same density-dependent factors.

Zooplankton and Limnology

Except for a spike in 1995, a downward trend in zooplankton densities and biomass has been ongoing since the first recorded zooplankton samples in 1987 (Figure 3). A slight reduction in the number of cladocerans is indicated, but copepods have all but disappeared. Biomass for zooplankton has dropped by 95% between 1987 and 2001 (Figure 4). The forage demands by sockeye fry and sticklebacks, caused by years of high escapements and plus stocking of sockeye fry, have resulted in a steep decline in zooplankton populations. It will likely take years for the zooplankton populations to recover, even if escapements are kept low. The zooplankton populations may now be depleted to the extent that lake fertilization will not speed a recovery (Koenings and Kyle 1997).

We cannot conclusively establish a relationship between enhancement activities and changes in nitrogen and phosphorus levels within Chilkat Lake, based on the limnological measurements we currently have. The effects of the lake stocking are confounded with the effects of the large escapement and natural production, as the fry stocking occurred in concert with some of the highest recorded escapements observed. Levels of nitrogen and phosphorus do not consistently trend up or down in conjunction with or in opposition to changes in the Chilkat Lake sockeye fry populations. The biotic structure of Chilkat Lake is relatively complex, and more than one trophic level separates the nutrients dissolved in the water from zooplankton predators. The situation is further complicated by the lag times between the population cycles of the predators (juvenile sockeye salmon) and the prey (the zooplankton). All of these factors obscure relationships between the nutrients, mainly nitrogen and phosphorus, and the stocking events, provided such relationships actually exist. Some nutrients, such as total filterable nitrogen (TFP) exhibit interesting trends in parts of the time series (Figure 5), but do not track the zooplankton population levels or smolt numbers throughout the entire period of study.

Due to its location, Chilkat Lake has been categorized as a coastal lake, and decisions about enhancement strategies have been based on its location, potential high primary productivity, and initially high zooplankton levels (Barto 1995, David Barto, ADF&G, *unpublished data*). However, data from lake sediment cores suggest that Chilkat Lake was more productive 100 years ago than in the recent past (David Barto, ADF&G, *personal communication*).

Enhancement

In the late 1980s, NSRAA approached ADF&G with a proposal to enhance the Chilkat Lake sockeye salmon stock. The two possible avenues of enhancement considered were, (1) lake fertilization to increase the nutrient base, and (2) increasing the number of sockeye salmon by taking eggs from fish spawning in Chilkat Lake, incubating them, and "back planting" the resultant fry into Chilkat Lake the following spring. The lake fertilization option was rejected out of hand, because nutrient levels in the lake were already some of the highest found in Southeast Alaska (Barto 1996).

The lake stocking was originally recommended by ADF&G limnologists. They concluded that the number of fry needed for full utilization of the lake's zooplankton was inadequate, based on the "euphotic volume method" (Koenings and Burkett 1987). Also, ADF&G research and management biologists assumed that wild sockeye escapements into Chilkat Lake would remain constant at about 70,000 fish annually. The euphotic volume method has since fallen out of favor with ADF&G as a method of estimating lake productivity, because of its poor predictive characteristics (Hal Geiger, ADF&G, *personal communication*; Edmundson and Mazumder 2000). ADF&G conducted a five-year limnology study from 1987 to 1991 to determine the feasibility of enhancement, and the study's author recommended that the lake stocking move forward.

In order to track the results of fry stocking, NSRAA was required to monitor the nutrient levels in the lake, the zooplankton levels in the lake, the number of fish sacrificed for broodstock, the number of eggs taken, the number of fry released, and the estimates of sockeye smolt emigration.

NSRAA took water and nutrient samples two or more times per year, took zooplankton samples twice a month between May and November, and instituted a smolt mark—recapture project at the Chilkat Lake weir to estimate the total smolt emigration

The first egg take occurred in 1993. That year had the highest recorded weir count on record: 210,000 sockeye salmon (Table 1). Mark—recapture estimates in later years suggest that actual escapement was 2 to 5 times the size of the weir count.

From the 1993 egg take, 4.4 million fry were reared, and then stocked into Chilkat Lake in 1994. The fry had been marked with a thermal otolith mark, to distinguish them from wild sockeye salmon. Based on the mark—recapture studies conducted by NSRAA on smolt leaving Chilkat Lake, the 1994 stocking produced about 1 million smolts, of which 690 thousand emigrated as age-1 fish in 1995, and 330 thousand emigrated in 1996 as age-2 fish.

NSRAA stocked the lake from 1994 to 1997, and again in 2001. For the earliest 4 stockings, the fry survival remained high for 3 out of 4 years, but the percentage of enhanced smolts migrating as age 1.0 decreased from 68% in the 1994 stocking, to 33% in the 1997 stocking (Table 3). The 2001 stocking has produced miniscule numbers of smolt.

As the egg takes and fry stockings proceeded, ADF&G became concerned about the effects of high fry populations on their food source. Therefore, in 1997, ADF&G came to an understanding with NSRAA that stocking would proceed only if monitored variables attained specific thresholds or trigger points. The variables monitored were the average size of emigrating smolts that had spent one year in fresh water (age-1.0 smolts), the total weight (biomass) of age-1.0 smolts in the emigration, and the estimated density of zooplankton in July and August. The agreed upon trigger points for age-1.0 smolt were an average size of 5.0 grams, and an estimated smolt biomass of 13,000 kg. Because of failure to attain one of the trigger points, NSRAA did not stock fry in 1998 to 2000, 2002, and 2003.

Between 1994 and 2002, the average weight of age-1.0 smolt from Chilkat Lake decreased by nearly 50%, and the number and percentage of age-1.0 smolt has dropped substantially (Figure 6, Table 4). Despite the considerable drop in mean smolt weight, and signs of severe overgrazing of zooplankton populations, the mean weight of age-1.0 smolt was still above 5 grams.

The age composition of both wild and enhanced Chilkat Lake smolts is highly variable, and reflects fluctuating escapements and food availability for fry. The proportion of age 1.0 smolts studied varied from 76% in 1989, to 7.1% in 2000 (Table 4).

Supplemental stocking of sockeye fry into Chilkat Lake has not increased the lake's sockeye productivity, and this effort has greatly compromised our ability to find a statistical relationship between stock size and subsequent return. Drastic reductions in the zooplankton populations, in concert with reduced emigration of age-1.0 sockeye smolts, are strong indicators of overutilization of the food base. The high natural escapements in the 1990s may have caused a reduction in the zooplankton populations, even without the added food demands that smolt stocking imposed. Stocking of hatchery-incubated fry probably intensified the zooplankton decline. Given the degree of decline, it could take many years for the zooplankton populations to rebound (Koenings and Kyle 1997).

Between 1999 and 2002, the adult returns from enhanced Chilkat Lake fish comprised a mean proportion of 14 percent of the Lynn Canal sockeye catches (Table 5). In 1998, enhanced returns comprised over 30% of the catch, but their timing was earlier than most of the Chilkat Lake sockeye salmon, and resembled that of the mainstem Chilkat River stocks. Given concerns about the size of mainstem Chilkat River stocks, commercial fishing was restricted during the early portion of the season, and the enhanced fish were not fully exploited (Randall Bachman, ADF&G, *personal communication*). The earlier timing of the returning enhanced fish may have been an artifact of the egg takes. Spawning in Chilkat Lake occurs from September through December. By taking eggs from early spawners in September or early October, the aquaculture association may have skewed the timing of the enhanced fish towards the earliest returning Chilkat Lake sockeye stocks.

Hydroacoustics

ADF&G has estimated Chilkat Lake sockeye smolt abundance on a regular basis via hydroacoustic surveys since 1987. Tow nets were used to apportion hydroacoustic estimates by species. From 1987 to the present, the total estimated number of small fish in the lake has not changed meaningfully between pre-stocking and post-stocking estimates. The estimated number of sockeye fry has decreased by over 90% between 1987 and 2002.

When NSRAA planted fry in Chilkat Lake, they did so under the assumption that stickleback numbers would decrease as sockeye fry numbers increased, thereby maintaining an equivalent demand on zooplankton. The largest estimate of sockeye fry abundance on record was 4.0 million fry in 1994. The number dropped to 1.5 million in 1996, hovered at around 1.5 million from 1997 to 2000, and dropped to less than 100 thousand in 2001 (Table 6). Except for the 1994 survey, overall hydroacoustic estimates have remained within the ranges seen before stocking. Stickleback numbers in the tow nets have increased to 98% of the samples (Figure 7).

The sonar technicians use results of the tow net samples to apportion the hydroacoustic data by species, and unrepresentative tow net samples are likely obscuring the actual sockeye fry and stickleback population trends. Limitations in the tow netting equipment are probably responsible for the questionable species apportionment. First of all, the small size of the boat likely causes bias in the samples. It cannot pull the tow net fast enough to capture the larger fish, resulting in larger fish being underrepresented in the samples. Secondly, the net can reach depths of 20 meters at most, and cannot sample fish below that depth. Sockeye fry live in depths up to 40 meters. The sonar technicians are assuming that species composition remains the same from the surface to 40 meters depth (Malcolm McEwen, ADF&G, *personal communication*).

No lake-specific study has been conducted to determine the daily or seasonal migrations of Chilkat sockeye salmon or three-spined sticklebacks (*Gasterosteus aculeatus*). We do not know whether variables such as time of day, water temperature, predator relationships, and schooling density, are biasing the samples taken with the tow net.

CONCLUSIONS

Like many sockeye populations within Alaska, too little is known about Chilkat Lake sockeye stocks. The Chilkat Lake sockeye salmon population has undergone drastic changes since 1880. Some of the most recent negative changes are associated with efforts to enhance or reestablish historical sockeye salmon abundance. The most significant problem in managing Chilkat Lake sockeye runs is the lack of accurate and precise escapement data. The mark–recapture escapement estimates have not agreed with the weir counts. The difference between the two different escapement estimates is quite variable (Table 2). In some years, over 100,000 fish passed the weir uncounted. The lack of accurate escapement estimates obscures the relationship between size of escapement and returns of adult offspring. Management of salmon fisheries becomes much more difficult and tenuous without consistent and accurate data.

We believe that preserving long-term stock assessment programs should continue to be one of the highest priorities for the Alaska Department of Fish and Game. These programs form the basis for understanding the causes of abundance fluctuations and overall status of the resource. Additionally, these long-term projects underpin inseason management. Because of the two to six year life span of sockeye salmon, many years of data are necessary to monitor the spawning abundance and subsequent returns of a few cohorts. Omission of a single year of data can add considerable uncertainty to an analysis (Riffe and Clark 2003).

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Table 1. Estimated spawning escapements, commercial harvest, total run size, and exploitation rates of Chilkat Lake sockeye salmon, 1976 - 2002.

Year	Weir Counts	Mark-Recapture Estimates	Catch	Estimated Exploitation Rate
1976	69,700		59,300	*n/a*
1977	41,000		41,400	*n/a*
1978	67,500		89,600	*n/a*
1979	80,600		116,000	*n/a*
1980	95,300		30,700	*n/a*
1981	84,100		48,500	*n/a*
1982	80,200		127,000	*n/a*
1983	134,200		123,900	*n/a*
1984	115,300		98,200	*n/a*
1985	57,700		135,500	*n/a*
1986	23,900		168,400	*n/a*
1987	48,600		70,100	*n/a*
1988	27,600		76,500	*n/a*
1989	140,500		159,500	*n/a*
1990	60,200		147,100	*n/a*
1991	52,900		59,800	*n/a*
1992	97,700		111,900	*n/a*
1993	209,700		100,700	*n/a*
1994	80,800	153,500	122,200	44.3%
1995	59,600	184,500 [a/]	63,400	25.6%
1996	*no weir*	262,900	96,400	26.8%
1997	*no weir*	238,800	70,100	22.7%
1998	*no weir*	211,100	120,600	36.4%
1999	129,500	236,400	149,700	38.8%
2000	47,100	131,300	78,900	37.5%
2001	76,300	131,700	58,900	30.9%
2002	65,100	137,600	47,300	25.6%

[a] *Estimate was derived from marking experiment at the weir.*

Table 2. Comparison of Chilkat Lake weir counts with Chilkat River fish wheel mark–recapture estimates, 1994-2002.

Year	Weir Count	Fish Wheel Mark/Recap. Esc. Estimate	Difference	Percent Difference
1994	80,800	153,500	72,700	89.98%
1995	59,600	284,100	224,500	376.68%
1996	*no weir*	262,900		
1997	*no weir*	238,800		
1998	*no weir*	211,100		
1999	129,500	236,400	106,900	82.55%
2000	47,100	131,300	84,200	178.77%
2001	76,300	131,700	55,400	72.61%
2002	65,100	137,600	72,500	111.37%

Table 3. Chilkat Lake sockeye salmon stocking history, number of enhanced smolts produced, and estimated survival rates for each stocking year, 1994 to 2002.

Year Stocked	Number of Fry Stocked	Smolts Produced Age 1.	Age 2.	Age 3	Total Smolts Produced	Percent Fry to Smolt Survival
1994	4,400,000	686,000	330,000	0	1,016,000	23.1%
1995	2,394,000	269,000	377,000	16,000	662,000	27.7%
1996	2,691,000	99,000	34,000	25,000	158,000	5.9%
1997	2,807,000	221,000	447,000	0	668,000	23.8%
1998	0					
1999	0					
2000	0					
2001	2,699,000	2,000	110,000			
2002	0					

Table 4. Average lengths and weights of Chilkat Lake sockeye smolt for 1989, 1990, and 1994 to 2002.

Year	Percent of Outmigration by Age			Average Length in mm.			Average Weight in g.		
	age-1.0	age-2.0	age-3.0	age-1.0	age-2.0	age-3.0	age-1.0	age-2.0	age-3.0
1989	76.0%	24.0%		100.2	121.0		8.9	14.6	
1990	27.0%	73.0%		103.9	118.9		10.0	14.8	
1991									
1992									
1993									
1994	51.0%	49.0%		102.3	119.5		9.9	14.8	
1995	62.0%	37.0%	4.0%	92.5	115.4	147.4	7.1	13.2	27.2
1996	42.0%	58.0%	2.0%	86.3	107.2	185.0	5.7	10.3	56.0
1997	13.0%	86.0%	1.0%	95.2	101.2	154.5	7.0	8.8	34.4
1998	64.0%	27.0%	9.0%	92.7	109.4	138.3	7.3	11.2	22.7
1999	34.0%	64.0%	2.0%	88.1	107.6	155.8	5.3	9.5	37.7
2000	7.1%	92.6%	0.3%	93.8	104.8	120.4	7.1	9.4	14.3
2001	47.0%	49.6%	3.4%	92.5	113.4	131.5	6.6	12.1	19.0
2002	26.8%	72.9%	0.2%	85.9	92.5	175.0	5.3	6.4	38.7
Average	40.9%	57.6%	2.7%	93.9	110.1	151.0	7.3	11.4	31.2

Table 5. Number of enhanced sockeye salmon caught commercially in Lynn Canal, percent of total harvest comprised by enhanced fish, and estimated number of enhanced fish in Chilkat Lake escapement, 1998 to 2002.

Year	Est. Number of Enhanced in Catch	Total Harvest	Percent Enhanced in Catch	Est. Number of Enhanced in Escapement	Total Escapment	Percent Enhanced in Escapement	Est Total Return of Enhanced Fish
1998	39,700	120,600	32.9%	62,800	211,100	29.7%	102,500
1999	28,400	149,700	19.0%	32,100	236,400	13.6%	60,500
2000	12,100	78,900	15.3%	10,600	131,300	8.1%	22,700
2001	5,400	58,900	9.2%	13,300	131,700	10.1%	18,700
2002	6,000	47,300	12.7%	7,500	131,600	5.7%	13,500

Table 6. Results of tow netting, and estimates of population sizes of resident small fish, based on hydroacoustic surveys of Chilkat Lake, 1987 to 2002. [1/]

Year	No. of tows	Total Estimate	Total Sample Size	Tow Net Sample Composition			Percent Species compositions.			Estimated Numbers of Fish		
				Sockeye	Stickleback	Other	Sockeye	Stickleback	Other	Sockeye	Stickleback	Other
1987	(6-tows)	5,145,000	232	38	192	2	16.4%	82.8%	0.9%	842,000	4,303,000	
1988	(6-tows)	3,046,000	333	75	255	3	22.5%	76.6%	0.9%	686,000	2,360,000	
1989	(6-tows)	3,518,000	179	140	32	7	78.2%	17.9%	3.9%	2,751,000	766,000	1,000
1990	(6-tows)	2,439,000	350	171	179	0	48.9%	51.1%	0.0%	1,192,000	1,247,000	
1991	(6-tows)	2,717,000	181	89	92	0	49.2%	50.8%	0.0%	1,336,000	1,381,000	
1992	*hydroacoustic survey not done*											
1993	*hydroacoustic survey not done*											
1994	(6-tows)	9,050,000	407	171	219	17	42.0%	53.8%	4.2%	3,802,000	5,244,000	4,000
1995	(4-tows)	5,067,000	171	53	116	2	31.0%	67.8%	1.2%	1,570,000	3,496,000	1,000
1996	*equipment problems - unable to calculate estimate*											
1997	(16-tows)	3,798,000	402	147	247	8	36.6%	61.4%	2.0%	1,389,000	2,408,000	1,000
1998	(15-tows)	2,471,000	100	78	21	1	78.0%	21.0%	1.0%	1,927,000	544,000	
1999	(6-tows)	2,104,000	10	9	1	0	90.0%	10.0%	0.0%	1,894,000	210,000	
2000	(3-tows)	5,220,000	25	11	13	1	44.0%	52.0%	4.0%	2,297,000	2,921,000	2,000
2001	(3-tows)	4,991,000	107	2	104	1	1.9%	97.2%	0.9%	93,000	4,897,500	500
2002	(4-tows)	4,809,000	201	11	188	2	5.5%	93.5%	1.0%	263,000	4,545,500	500

[1/] Based upon Surface area of 8,442,000 m^2 (minus 5 meter contour) and analysis of 0-27m depths.

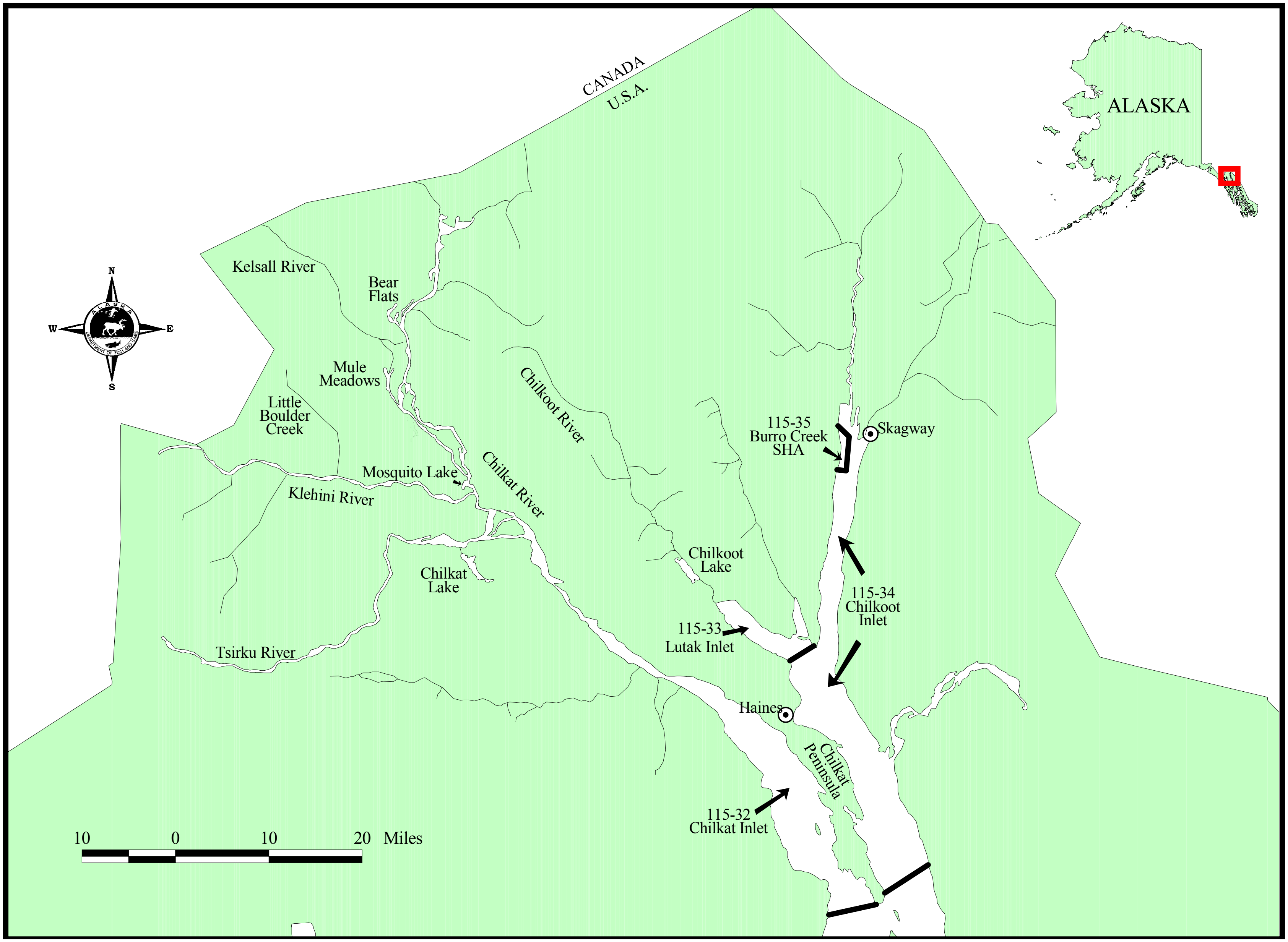

Figure 1. Map of Upper Lynn Canal, Chilkat, and Chilkoot Lakes, Alaska.

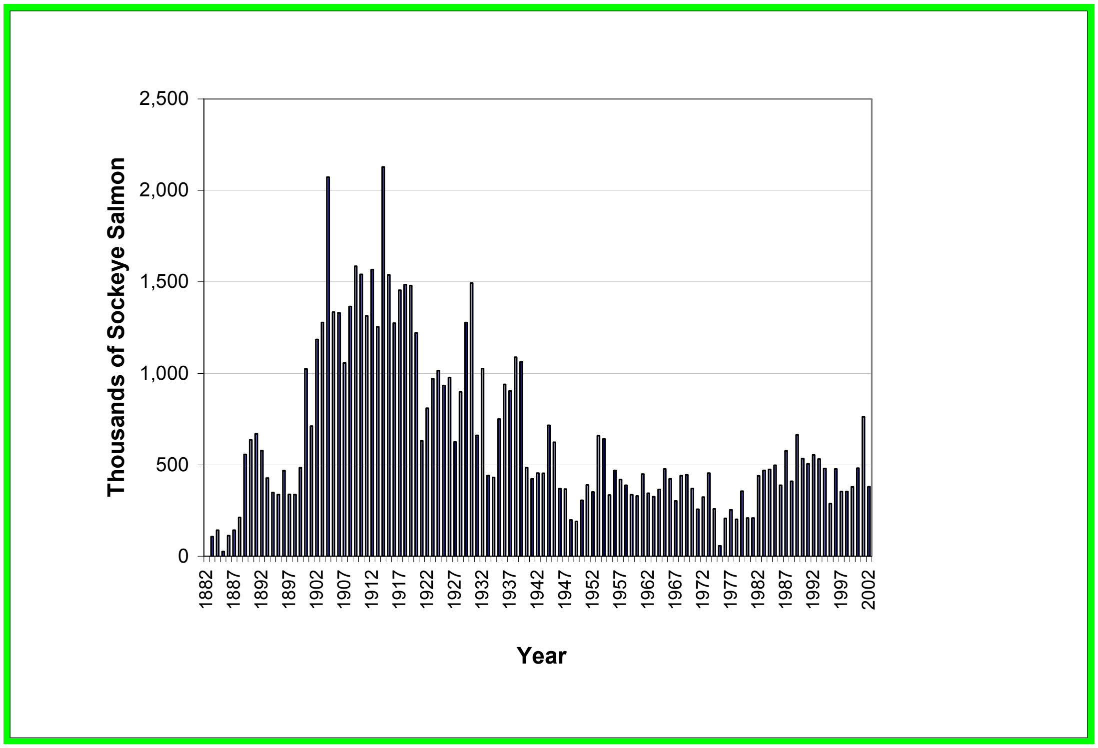

Figure 2. Annual harvest of sockeye salmon in Northern Southeast Alaska, 1883 to 2002.

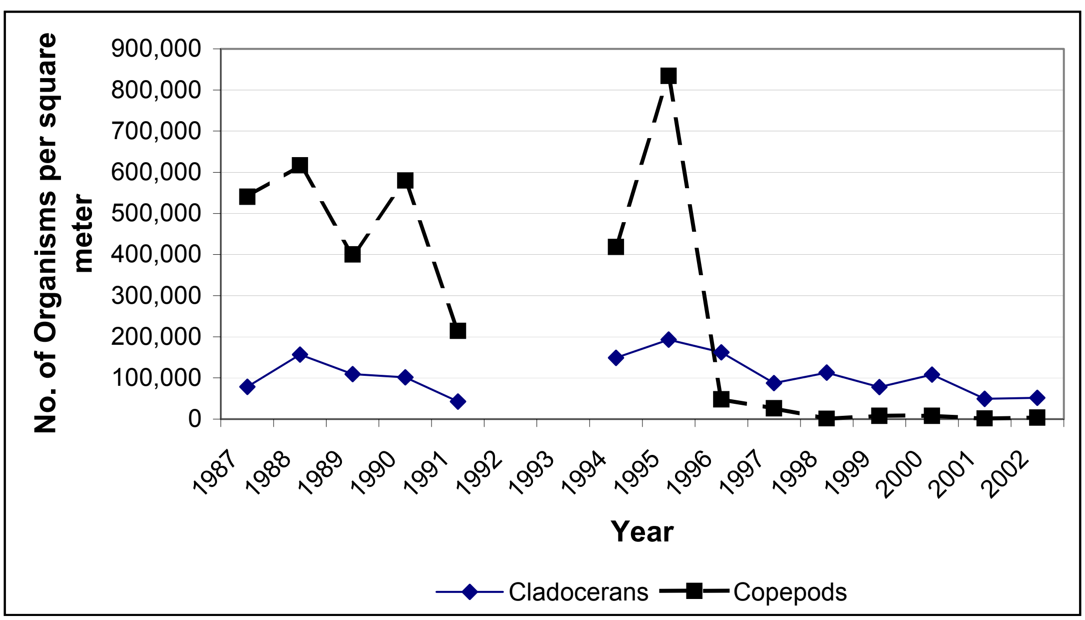

Figure 3. Mean density of cladoceran and copepod zooplankton in Chilkat Lake, from 1987 to 2002.

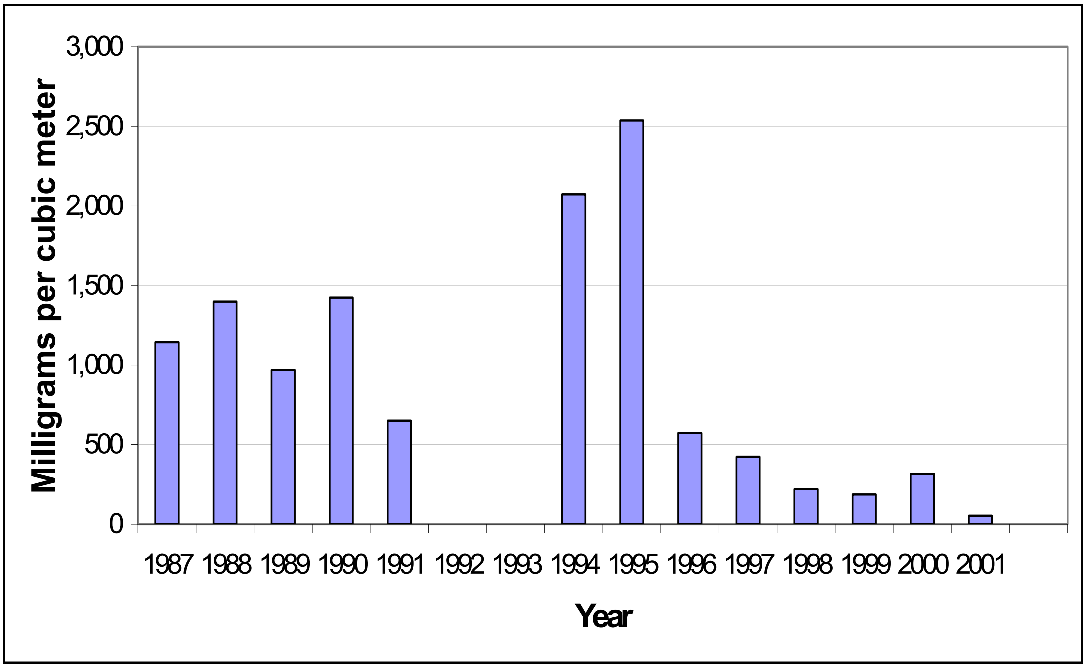

Figure 4. Zooplankton biomass in Chilkat Lake, 1987 to 2002.

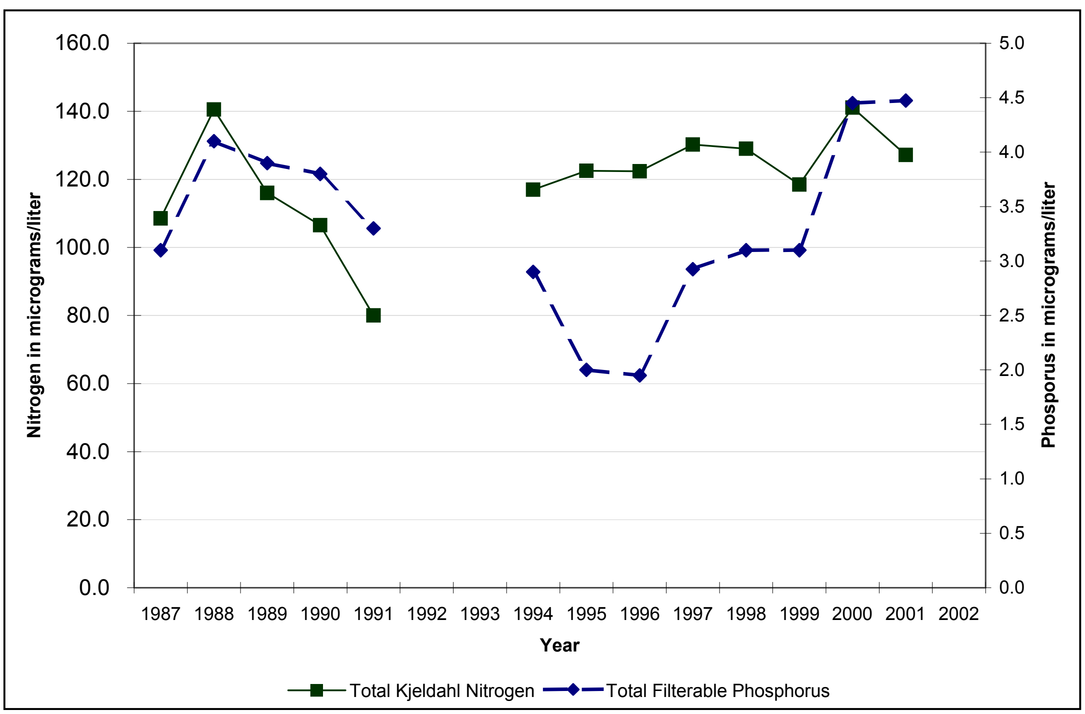

Figure 5. Mean annual levels of total Kjeldahl nitrogen and total filterable phosphorus at one meter depth, in Chilkat Lake, from 1987 to 2002.

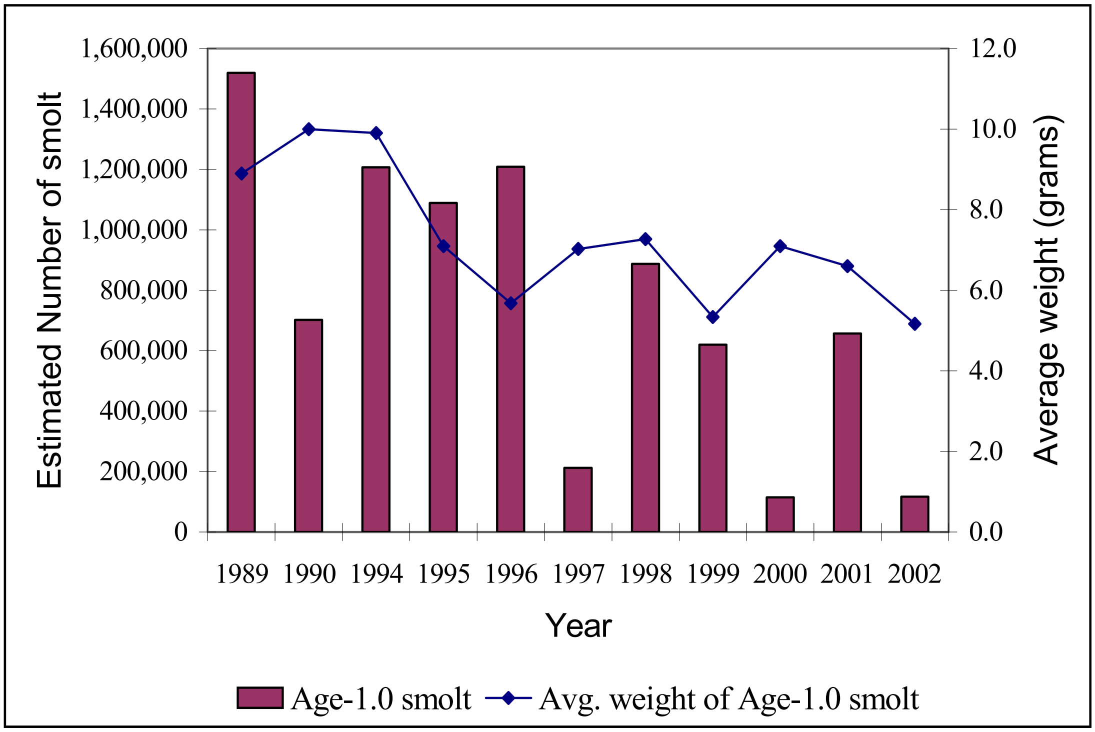

Figure 6. Number and average weight of age-1.0 sockeye smolt that exited Chilkat Lake, 1989 to 2002.

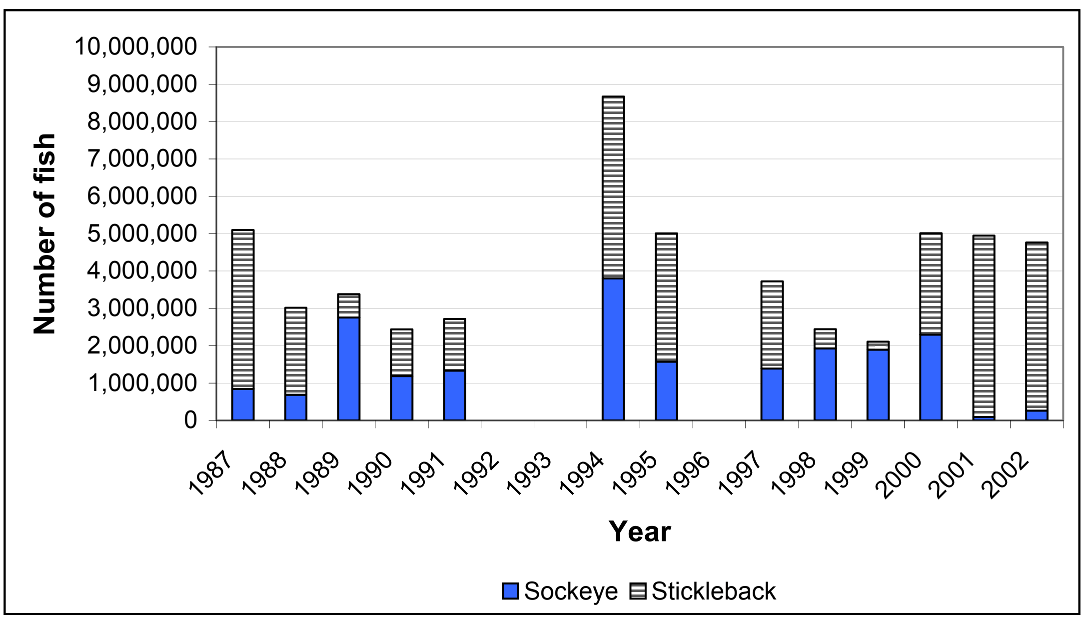

Figure 7. Hydroacoustic estimates of number of sockeye fry and three-spined sticklebacks in Chilkat Lake, 1987 to 2002.

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